

Radiology Corner

Mild Traumatic Brain Injury and Conduction Aphasia from a Close Proximity Blast Resulting in Arcuate Fasciculus Damage Diagnosed on DTI Tractography

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Note: This is the full text version of the radiology corner question published in the October 2009 issue, with the abbreviated answer in the November 2009 issue.

The authors present a case demonstrating that a blast injury was associated with both conduction aphasia and an abnormality in the left Arcuate Fasciculus (AF) on MR DTI (Diffusion Tensor Imaging). In addition, this study showed the presence of conduction aprosodia in the setting of damage to the homologous area in the right hemisphere (hereafter referred to as the right homologue of the AF). In prior research, diffusion tensor images have revealed injuries invisible to standard structural imaging.¹ Our finding is consistent with a previous diffusion tensor study demonstrating that damage to the AF is associated with conduction aphasia.² Based on the patient's length of posttraumatic amnesia this patient's second TBI would be classified as mild and unlikely to be associated with enduring cognitive deficits, and yet we have observed evidence from both DTI and behavior that there is enduring dysfunction. This case report suggests that further study of patients with complaints following blast injuries is warranted, particularly with advanced imaging techniques such as DTI. Of particular interest, change over time in white matter tracts, observed using sequential DTI, could show improvement of connectivity.

Introduction

A 23-year-old male was exposed to two blasts in 2004. He was about five feet from each blast wearing a helmet and goggles. Following the second blast (about two months after the first blast) he reported headaches, intermittent tinnitus without hearing loss, and a conduction aphasia on the Boston Diagnostic Aphasia exam. The patient had an MRI with DTI and a PET scan (CT was negative). Fig. 1 is the DTI tractography of our case (upper image) with a normal patient's DTI shown in the lower image for comparison. The Arcuate

Fasciculus is labeled Anterior (A, near Brocas Area), Middle of tract (M) and Posterior (P).

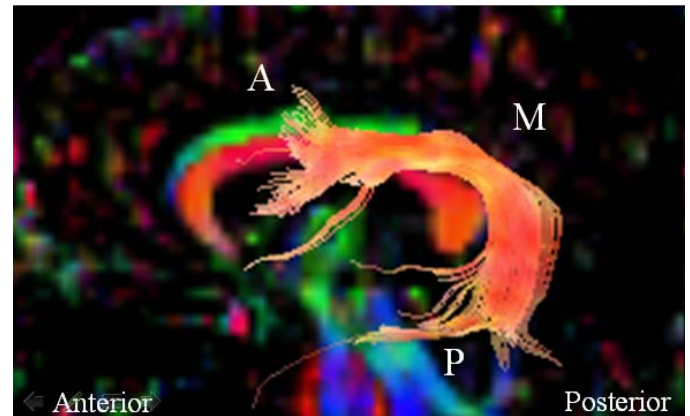
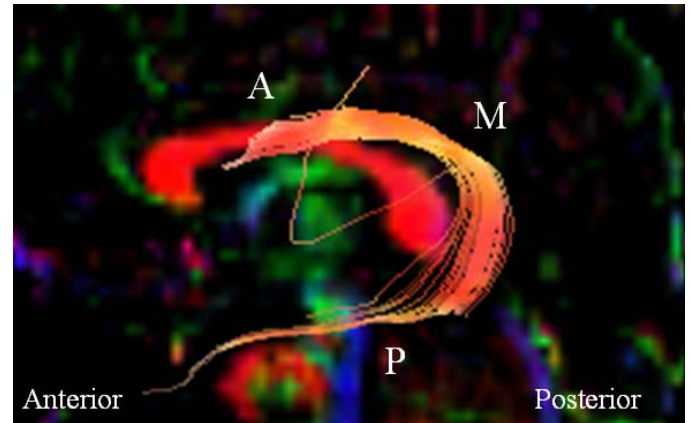


Fig. 1: DTI demonstrating left Arcuate Fasciculus (in orange) of patient (upper image) and normal in lower image. Note the patient's fiber tract is much thinner than that of the control. A is the anterior. M is the Middle and P is Posterior section of the AF.

Summary of Imaging Findings

Conventional MRI (1.5 Tesla, without DTI) was performed in March 2007 and a PET in July 2007. They were both initially assessed as normal, however, in retrospect the PET seems to show some asymmetry in the left temporal region. Special MRI (4 Tesla with DTI), with tractography of the left AF and its homologue on the right (Figs. 1, 2, and 3) was done soon after the clinical MR (March 2007). The sizes of the AF and its homologue on the right in this patient are smaller than those of the controls (one control is shown, but is

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representative of several other normals in whom the tractography was successful). The width of the AF is thinner in the patient on visual inspection in Fig. 1. On retrospective analysis of the PET, there was slightly decreased activity in the region of the anterior termination of the AF on the left. The DTI of the patient was repeated four months later after intensive speech and language therapy and tractography was similar with slight sprouting around the locations that appeared to have been sheared, particularly on the left side (Fig. 4). (See Figs 5 and 6 for the PET and MR images included in the original radiology question.) On retrospective review, the PET had a slight asymmetry of uptake in the temporal regions.

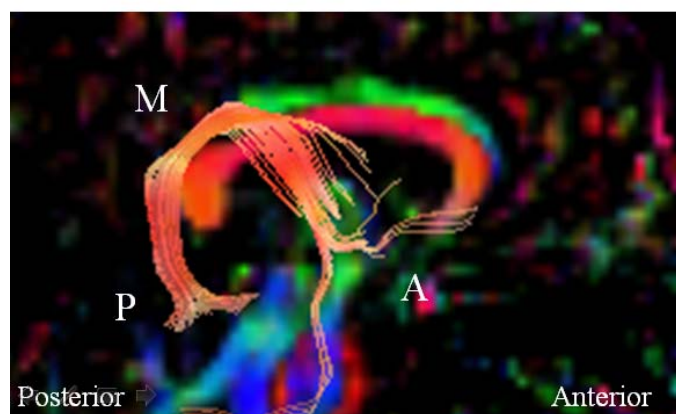
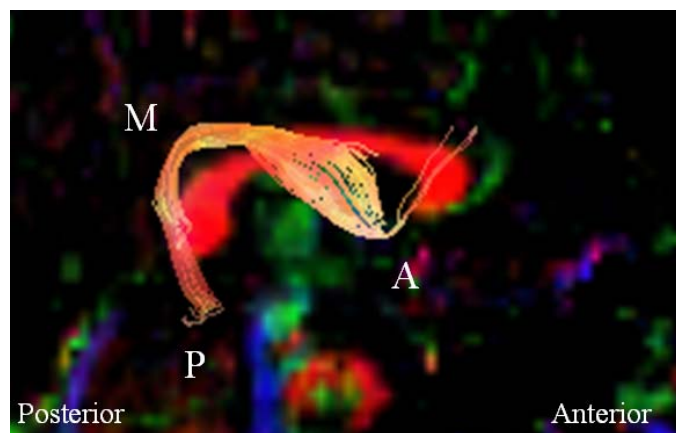


Fig. 2: Right homologue of the Arcuate Fasciculus of patient (above image) and normal in the below image.

Patient Discussion

History:

The patient is a 23-year-old Chinese American that is an Iraq War veteran (Operation Iraqi Freedom) who was having new onset of language difficulties and was referred for neuropsychological and speech pathology evaluation. He was exposed to two blast explosions by improvised explosive devices in 2004, approximately two months apart. After the first explosion in April, there was no loss of consciousness and no known residual symptoms. After the second of those exposures he experienced a loss of consciousness for approximately five minutes. He believed he was

approximately five feet from the blast and was wearing a helmet and non-ballistic goggles. His first memory upon regaining consciousness was being in the back of his own vehicle, having trouble hearing, and feeling “slow” and “dazed”. He underwent a physical examination and was returned to duty. Since the second blast, he has had headaches and tinnitus intermittently, but no residual hearing loss.

The patient completed 1½ years of college before entering the army and attempted to resume his studies to complete his degree after returning home in 2005. However, he became more socially withdrawn in part due to his difficulties with communication which are described below as conduction aphasia and neurogenic stuttering secondary to the aphasia. Also, his family felt that his personality had changed.

Summary of Findings, Diagnosis

Cognitive Evaluation:

The patient underwent evaluations in speech pathology, neuropsychology, and neuroradiology between September 2006 and February 2007. Initially, the patient complained of “slow vision”, difficulty hearing, impaired memory, stuttering, and “mumbling” speech. In continued evaluation, estimated premorbid intellectual ability was at least in the average range. Speech and language evaluation revealed a pattern of conduction aphasia on the Boston Diagnostic Aphasia examination. Spontaneous speech was characterized by hesitations and dysfluencies with reduced content but was grammatical. Comprehension was preserved. In contrast, confrontation naming was mildly impaired (1 SD below the mean) with errors characterized by literal paraphasias. Consistent with the diagnosis of conduction aphasia, literal paraphasias were observed in narrative writing and literal paraphasias were observed in sentence repetition. Struggle associated with paraphasic language production resulted in mild neurogenic stuttering. There was also some evidence of visuoconstructional dysfunction. In addition there was some moderate to severe difficulty with affective language processing on a measure (Tucker et al., 1977) in which he was asked to comprehend, produce, and repeat affectively (angry, happy, sad, and indifferent) modulated sentences. Consistent with an expressive/conduction aprosodia the patient was able to comprehend affective speech but was impaired in production and repetition. In contrast, measures of memory (Wechsler Memory Scale III) were in the Average to Superior range. The patient was also diagnosed with moderate to severe post-traumatic stress disorder.

Diagnosis:

Arcuate Fasciculus Damage seen on DTI in a blast-exposed soldier with mild traumatic brain injury (mTBI) with associated conduction aphasia

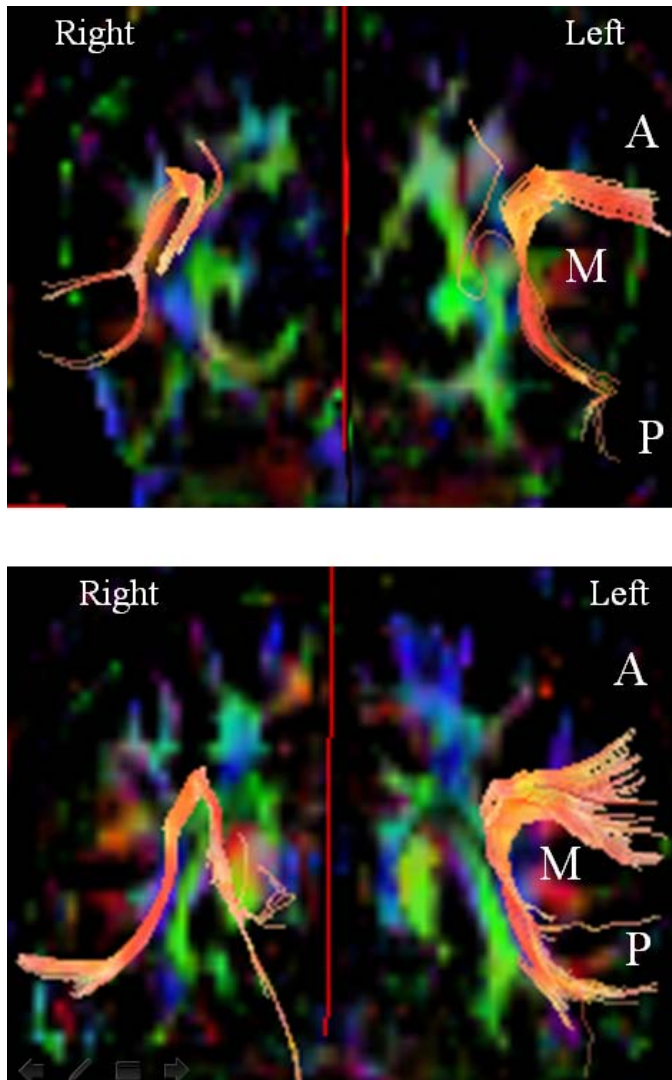


Fig. 3. Coronal AP view. Features on lateral view of our patient (above images) are apparent on AP view as well, particularly the branching at the Broca's area anterior end of the tract in the normal patient (below).

Discussion:

This is the first case report demonstrating that a blast injury was associated with both conduction aphasia and an abnormality in the left AF. Disconnection of brain fiber tracts has long been postulated to underlie certain cognitive impairments; however, there are now more sensitive MRI techniques to characterize the neural substrates of such damage. According to the Wernicke-Lichtheim Model of aphasia, the left arcuate fasciculus (AF) is a critical fiber tract connecting the two major language regions, Broca's and Wernicke's areas (Geschwind, 1970).³ Wernicke's area is generally believed to be involved in language comprehension and Broca's area to be involved in language production, although the actual neurobiology is more complex.⁴ One of the important predictions of this model is that disruptions in connections between processing centers can produce specific deficits. Disconnecting Broca's and Wernicke's areas results in conduction aphasia, a disorder in which patients can

comprehend grammatical speech, but there is a disproportionate deficit in repetition and production of content words. The reason for these deficits is that transfer of what is comprehended by the semantic processing system to the speech generation system is disrupted.

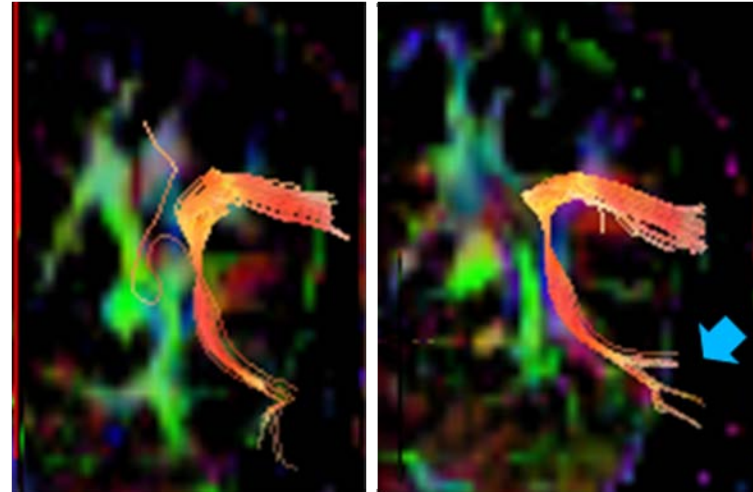


Fig. 4: Patient, coronal view of the left AF, initially (left) and 4 months later (right). Evidence of sprouting is indicated with an arrow.

Ross⁵ described a parallel model of emotion processing in the right hemisphere which predicted similar disconnection syndromes relating to the comprehension and production of prosodic factors underlying affective or emotional components of language (as opposed to linguistic prosody such as stress within a word). He termed this problem "aprosodia." In conduction aprosodia, patients are able to comprehend the emotion conveyed by the prosody, but there is disproportionate difficulty with matching affective prosody to propositional speech and with imitation of this prosody. In this case, the right homologue of the AF has been postulated to be critical for imitation of prosody.

Studies applying MRI techniques have demonstrated that damage to the AF is associated with conduction aphasia. (Yamanda et al., 2007) However, there has been no parallel study of conduction aprosodia. DTI and tractography are techniques that enable investigators to characterize the integrity of white matter tracts. Using DTI, Yamanda et al. (2007) demonstrated that a stroke with a lesion localized to the left AF was associated with conduction aphasia.

The case presented in this report is the first where an association has been found between conduction aphasia and damage to the AF on the left, and conduction aprosodia and damage to the homologous structure on the right, in a patient who experienced a traumatic brain injury due to a blast.



Fig. 5: PET showing a slight asymmetry in the temporal regions, with the less uptake in the left temporal region (arrow).

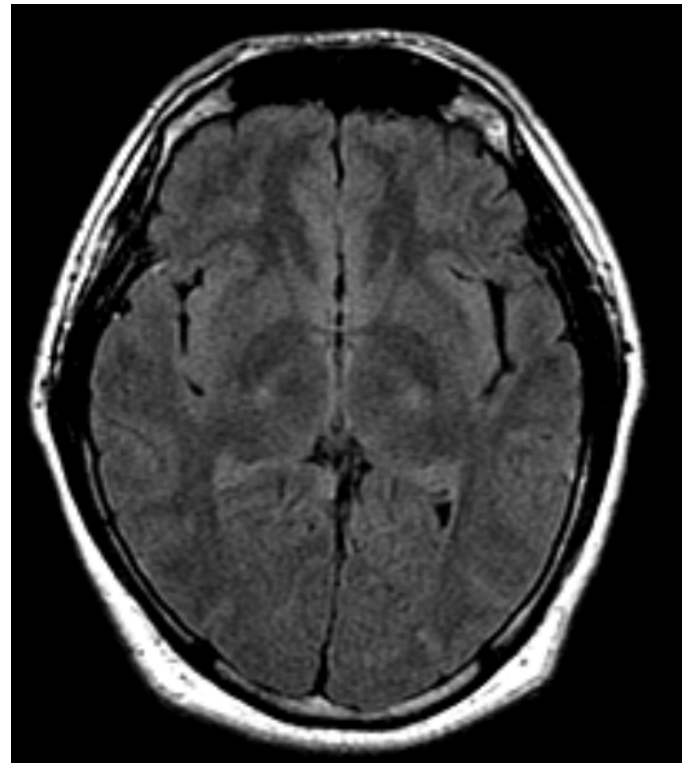


Fig. 6: Initial MRI on 1.5 Tesla without definite evidence of abnormality

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